

ECOLOGICAL TRANSFER OF RADIONUCLIDES AND HEAVY METALS AT NORM AND TENORM SITES IN NORWAY

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Fen Central Complex (FCC) in southern Norway is an area with thorium rich carbonatite rocks. Mining for iron and niobium, also present in abundance in these rocks, was conducted during past centuries. As a result today, technologically enriched naturally occurring radioactive materials (TENORM) sites are situated in area together with naturally occurring radioactive materials (NORM) rich sites. Recent dosimetric study showed up to 4 times higher annual radiation exposure doses for human population living there in comparison with other parts of Norway. Analysis of different samples from FCC showed increased concentrations of thorium (^{232}Th), uranium (^{238}U) and heavy metals - arsenic (As), lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn). The distribution of these pollutants was found to be highly heterogeneous, with several hot spots. Some of them were in the vicinity of houses or within easily accessible wooden area.

In order to see ecological transfer of both radionuclides and heavy metals, the concentrations in typical Fen plant and earthworms species were analyzed. Acid microwave decomposition of material and ICP-MS measurements were used in analysis. The sequential extraction of soil was conducted to obtain mobile soil fractions of radionuclides and heavy metals. Transfer factors and available transfer factors were calculated in relation to corresponding soil concentrations. Obtained transfer factors for ^{232}Th were in range from 5×10^{-5} to 3×10^{-2} and from 3×10^{-4} to 6×10^{-2} , for plants and earthworms, respectively. Similarly, transfer factors for ^{238}U were in range from 3×10^{-4} to 6×10^{-2} for plants and from 3×10^{-3} to 9×10^{-2} for earthworms. The highest transfer factors for ^{232}Th and ^{238}U were obtained for moss, lichen and earthworms. Metals Pb and Cd were also in the highest concentrations in moss. Essential metals like Cu and Zn were in the highest concentration in birch leaves.

These results for radionuclides were further put into the ERICA assessment tool to estimate radiological risk for living species in this area. Total exposure dose per terrestrial organism groups, calculated on the basis of internal exposure, confirmed that bryophytes and earthworms are the most sensitive and potentially vulnerable organisms in this area.

When it comes to assessing the radiation risk for terrestrial non-human species there is a knowledge gap and lack of data. Therefore, this study is important and will in future, involve more detailed investigation of effects on the most sensitive species.